The Amateur in You, Part 1

What have you been pondering?

Partial-wave antennas

When people talk about ham radio antennas, they often seem to mention a *quarter-wave antenna* or a *half-wave antenna*, and so forth. Will a *full-wave antenna* work? How about a *double-wave antenna*? It turns out that there are good reasons for using what I call a *partial-wave antenna* (a term I made up) over an antenna that's a full-wavelength long or longer.

Wavelength

In free space, radio signals travel the speed of light. We can calculate the wavelength of the signal if we know its frequency, because the relationship is speed of light = frequency times wavelength, or

sol = freq x wl, or **wl = sol ÷ freq**

in which "sol" means "speed of light" and "wl" means "wavelength". For example, a 146 MHz signal has a wavelength of

wl = sol ÷ freq

wl = 300 Mm/s ÷ 146 = 2.055 m

Velocity factor

Let's consider a simple wire that we might use for an antenna at a particular frequency. (We refer to that wire as an ***antenna element***, and can be other types of conductors too.) If we connect a signal source, like a radio, to that wire, it'll take some time for the signal to travel the length of the wire, typically slower than the speed of light. If the wire is made of copper, the signal travels in the wire at about 95% the speed of light, so we say that the wire has a ***velocity factor*** of 0.95.

Full-wave antenna

Even though one wavelength of a 146 MHz signal in free space is 2.055 m long, in a copper wire it's 2.055 m x 0.95 = 1.954 m. This way, a copper wire that's 1.954 m long is *one wavelength long* for 146 MHz, and if we were to make an antenna from that 1.954 m-long wire, we'd say that it's a ***full-wave antenna*** at the selected frequency (146 MHz). Obviously, a ***double-wave antenna*** is made from an antenna element that is twice the length of a full-wave antenna.

Partial-wave antenna

If we were to cut the element wire of a full-wave antenna in half, we would say that it's a ***half-wave antenna*** at the same frequency. If we were to cut it in half again, you can see that it's now a ***quarter-wave antenna*** at the same frequency. So, I'm referring to any of these less-than-full-wavelength antennas as a ***partial-wave antenna*** for convenience.

Antenna resonance

A wire that's a multiple of a quarter-wavelength can be made into an antenna that is ***resonant*** at its target frequency; that is, its feed-point (where the coax connects to the antenna) impedance is purely resistive. A quarter-wave antenna and a half-wave antenna exhibit feed point impedances that are well within the ranges for typical amateur operation.

On the other hand, a full-wave antenna, while resonant, has a very high feed point impedance, making it essentially unusable for amateur operation. It's still possible to make use of a full-wave antenna by reducing its huge feed point impedance, which is the theory behind the design of a folded dipole, a delta loop, and other loop-type antennas that are full-wavelengths long.

Antenna patterns

Another consideration for which antenna element lengths to select is ***antenna radiation***

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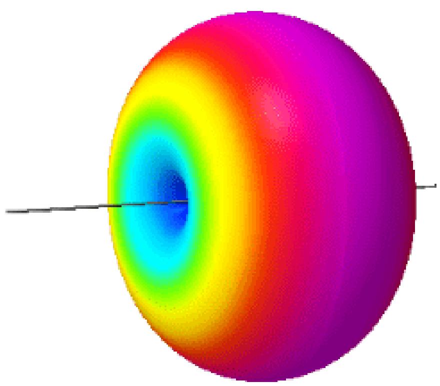
pattern, or simply *antenna pattern*, which is a two- or three-dimensional view of the relative strengths of signals radiating from an antenna in all directions. An antenna's pattern is determined by a number of things, including its height above ground, its proximity to conductive objects, and yes, its element lengths.

For example, a half-wave dipole antenna installed way up high and away from anything conductive will exhibit a pattern that resembles a large donut on its side, while a Yagi antenna contains a half-wave dipole that's got several nearby conductors called *parasitic elements*, which drastically affect its pattern from that of an ordinary dipole.



A quarter-wave antenna and half-wave antenna tend to produce a pattern that indicates their signals are emanated both effectively and efficiently. A full-wave antenna, on the other hand, produces many lobes in its pattern, indicating wasted signal in multiple directions. The same applies to a double-wave antenna.

Other partial-wave antennas

In the world of VHF radio, we often hear of a ***5/8-wave antenna***, whose elements are 5/8 of a wavelength long. That might seem like an odd fraction of a wavelength, but it's popular with VHF antenna manufacturers because it's effective, efficient, and easy to make. Several well-known mathematical antenna modeling software applications show that the 5/8-wave antenna is possibly the very best one for VHF because it possesses the most optimal balance between resonance, feed point impedance, and pattern, which includes gain.

Because the feed point impedance isn't perfect, however, the 5/8-wave antenna needs a ***counterpoise*** in the form of ***radials*** to help bring its impedance within a practical range. Will the same principles apply to an HF antenna? Yes, of course, but because their wavelengths are much longer, ground losses (including height above ground and soil conductivity) factor more significantly.

The ***7/8-wave antenna*** is another, though lesser-known, antenna designed primarily for VHF signals. It requires even more engineering than that of the 5/8-wave antenna to make it effective, including a special matching circuit. Its advantage is greater gain (more signal strength in its strongest direction), but at the cost of efficiency and feed point impedance.

Summary

A "partial-wave" antenna is one whose antenna element lengths are less than a full wavelength long with respect to a particular frequency, taking velocity factor into account. An antenna whose elements are multiples of one-quarter wavelength are resonant for a particular frequency. The quarter-wave antenna and half-wave antenna are useful because they are not only resonant, but exhibit a reasonable feed point impedance, something that is difficult for a full-wave antenna or double-wave antenna to achieve. Other partial-wave antennas exist in the amateur radio world, but are accompanied by their own challenges.

Noji Ratzlaff, KNØJI (kn0ji@arrl.net)